The Institute of Physics

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CONTENTS

NOTICES TO MEMBERS
Page 265

THE INSTITUTE'S HONORARY OFFICERS
Page 266

PHYSICS AND ENGINEERING
R. W. Sillars
Page 270

REVIEWS OF BOOKS
Page 276

NEWS OF MEMBERS
Page 282

FORTHCOMING INSTITUTE MEETINGS
Page 283

THE INSTITUTE'S JOURNALS
Page 286

The Bulletin is published by The Institute of Physics for circulation to its members ; copies should not be placed in libraries.

Notices to Members

Board and Committee Meetings

Members wishing to transfer to another grade of membership and those asked to sponsor applications may find it helpful to have the dates of meetings of the Board and of the Membership and Examinations Committee for the remainder of the session.

Membership and Examinations Committee (Thursdays)	*Board (Tuesdays)*
1956 November 22	1956 December 4
1957 February 21	1957 March 5
April 25	May 7
June 20	July 2
September 19	

Technical College Diplomas

The Board has agreed to give full recognition to a Diploma in Physics to be awarded by the Northern Polytechnic, London. Details of the other college Diplomas so far recognized were given in the February *Bulletin*. The Board has also agreed to recognize a Diploma of Brighton Technical College, given on successful completion of a sandwich course ; the full-time course for the Brighton College Diploma has previously been recognized.

Symposium on Calder Hall Nuclear Power Plant

The British Nuclear Energy Conference symposium on the Calder Hall Nuclear Power Plant which is to be held on Thursday and Friday, November 22 and 23, 1956, will be at the Central Hall, Westminster, London, S.W.1, and not at The Institution of Civil Engineers as previously announced.

Mr. O. W Humphreys.

O. W. HUMPHREYS, B.Sc., M.I.E.E., F.Inst.P.

President, 1956-57

The Institute's new President, Mr. O. W. Humphreys, is one of that increasing number of physicists who have achieved outstanding success in the organization and administration of applied science in industry. Still only 53 years old, Mr. Humphreys occupies one of the most important and responsible posts in the whole field of applied research in this country. His professional career has been spent entirely with the Research Laboratories of The General Electric Co. Ltd. ; after graduating in physics at University College, London, in 1925 he joined the staff of the laboratories under the direction of Mr. (later Sir) Clifford Paterson, who was President of the Institute from 1937-39. Domestic and industrial heating was the field in which Mr. Humphreys specialized, after 1927 as the leader of the group concerned with this work. During the war he acted as Assistant Director and had general responsibility for the administration of the Laboratories.

In 1949 Sir Clifford Paterson, who had guided the development and growth of the Company's research activities since the end of the first world war, died suddenly, and Mr. Humphreys was appointed the Manager of the Laboratories. In 1951 he became the Director and in 1953 was given a seat on the Board of the Company. The total staff of the Research Laboratories now numbers nearly 3,000 people.

Mr. Humphreys has served many scientific and engineering organizations. He is on the Councils of three Research Associations ; an ex-member of Council and Faraday Lecturer of the Institution of Electrical Engineers ; Chairman of the Telecommunications Industry Standards Committee and a member of the Engineering Divisional Council of the British Standards Institution ; a member of the British National Committee of the International Electro-technical Commission and Chairman of the Special International Committee on Radio Interference. He has been a Fellow of the Institute since 1942 and has served on the Board since 1951.

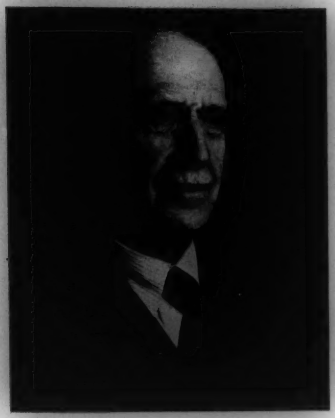
Bernard P. Dudding, M.B.E., A.R.C.S., Ph.D., F.Inst.P.

Vice-President

The vacancy for a Vice-President caused by the election of Mr. Humphreys to the Presidency has been filled by Dr. Dudding, who was Honorary Secretary from 1946 to 1956.

Born in 1885, Dr. Dudding began an indentured apprenticeship in the Royal Naval Dockyard, Chatham, in 1900. At the end of it he obtained a National Scholarship to the Royal College of Science, London, where he obtained a first-class A.R.C.S. Diploma in physics in 1909. A year later he was appointed assistant to Mr. (later Sir) Clifford Paterson, who was then in charge of the Electrotechnic Division of the National Physical Laboratory.

In July, 1916, Dr. Dudding signed an agreement with The General Electric Company to join Clifford Paterson who had accepted an invitation to found the Research Laboratories of the Company. He was thus one of the first two members of the staff of the organization with which he is still connected. In the 32 years which Dr. Dudding has spent with the service of the company, he has covered a wide range of scientific, technical and human problems and he has been particularly concerned with two main technical interests, glass and statistics.



He is a Founder Fellow of the Society of Glass Technology and was its President, 1934-36, and President of the International Congress on Glass in 1936. He became Honorary Secretary of the provisional International Commission on Glass in 1948 and of the newly constituted International Commission in 1950.

Dr. Dudding was largely instrumental in 1934 in establishing the Royal Statistical Society's Industrial and Agricultural Research section, from which, in 1945, the Industrial Applications section developed, with Dr. Dudding as its first Chairman. In 1949 he was elected the sole Vice-President of the newly formed Association of Incorporated Statisticians.

Dr. Dudding became a Fellow of The Institute of Physics in 1921.

Professor F. A. Vick, O.B.E., Ph.D., A.M.I.E.E., F.Inst.P.
Honorary Secretary

Professor Vick, who now succeeds Dr. Dudding as Honorary Secretary, has been one of the Institute's most active members during the post-war years.

Now 45 years old, Professor Vick is a graduate of the University of Birmingham and before the war lectured in physics at University College, London. In 1939 he joined the scientific staff of the Ministry of Supply and became Assistant Director of Research in charge of general physics, for which work he was awarded the O.B.E. Shortly before the end of the war he joined the physics staff of the University of Manchester under Professor Blackett, and in 1950 became the first Professor of Physics in the new University College of North Staffordshire. He also served the College as Vice- and Acting-Principal.

Becoming an Associate of the Institute in 1936 and a Fellow in 1941, Professor Vick has served as Honorary Secretary and as Chairman of the Manchester and District Branch. He served on the Board from 1946 to 1951 and in 1953 again became a member of the Board as a Vice-President. He has served on almost all of the standing Committees of the Institute, and on the Committees of the Electronics Group and the Education Group. He has also been one of the examiners for the Graduateship examination.

James Taylor, M.B.E., D.Sc., F.R.I.C., F.Inst.P.
Honorary Treasurer

Dr. James Taylor, the Institute's new Treasurer, was a student at Armstrong College, Newcastle-upon-Tyne, and graduated in the University of Durham in 1923 with first-class honours in physics. He subsequently carried out research in physics at Newcastle, gaining the M.Sc. and, in 1925, his Ph.D. For the next three years he was engaged in physical research at the Sorbonne, the University of Utrecht, and Trinity College Cambridge. He was awarded the doctor's degree in physics and mathematics (*cum laude*) in the University of Utrecht in 1928 and D.Sc. (Dunelm) in 1930. In 1928 he joined the staff of the Explosives Division of Imperial Chemical Industries Ltd. at Ardeer, Ayrshire, and has remained with the Company since then. At the end of the war, in 1946, Dr. Taylor was appointed Research Manager and Director of Research of the Nobel Division, and in 1951 he became Joint Managing Director. In the 18 years of his research career at Ardeer he had published some fifty papers on physical and chemical subjects. Dr. Taylor came to London in 1952 when he was appointed to the Main Board of Imperial Chemical Industries Ltd.

Dr. Taylor has been a Fellow of the Institute since 1948. He is also a Fellow of the Royal Institute of Chemistry and a Member of the Institute of Mining Engineers.

Physics and Engineering*

By R. W. SILLARS, B.A., D.Phil., M.I.E.E., F.Inst.P.

(*Metropolitan-Vickers Electrical Co. Ltd., Manchester*)

It came to my mind to talk of the relations between Physics and Engineering first through talking to young men who are uncertain whether their interests lie in the one or the other, and are dubious of approaching a frontier lest they find themselves on the wrong side, whichever the wrong side may be. Then again, it seemed to be of some intrinsic interest to study and reflect on the way these two sciences have interacted, and to note how the temporary boundaries between the two have shifted, contorted, leaving little enclaves here and there, on the whole enlarging so that engineering steadily claims a stance on the ground that physics covered before, while physics moves into new regions of understanding of the properties of space and of matter. We shall find that there is no frontier between the two, just a vaguely perceived junction which is often crossed and recrossed by men who start from either side.

Without drawing too sharp a line we generally regard the physicist as the natural philosopher, the contemplative man whose first interest is to understand, and to express as precisely as possible, the way events happen and the way matter is made in the inanimate world ; he is the man whose first thought is to study his environment and to be able to describe what exists and to predict what will happen, in the most exact terms he can.

The engineer is rather the man of action, who wishes to understand cause and effect so that he can arrange the effects as he wants them ; his first aim is to alter his environment so as to make it more agreeable to live in, to make something which will add to the convenience and comfort of his friends and himself.

The relation of physics (including mathematical physics) to engineering has no parallel in the relation of any other science to either of these two, in that the principles of engineering — mechanics, hydrodynamics, electromagnetism, stress analysis, heat transfer, thermodynamics and so forth—are all principles which were first studied as branches of natural philosophy and then taken as working rules for engineering. Other sciences such as metallurgy and chemistry, it is true, provide information about the behaviour of materials, and provide new materials but do not, as physics does from time to time, add new basic patterns to the engineer's methods of thought and design.

Many engineering design methods consist of physical principles and discoveries codified into a form in which they can be grasped and used without absorbing all the background which led to discovery and proof. This codification, long done for mechanics and thermodynamics, can be observed in progress now in the development of transistor techniques, where the physicists have been, and still are, at great pains to reduce the complicated and sophisticated concepts of solid state physics to terms which are convenient for the circuit engineer. This is not a process of mere translation. Elaborate experimental and theoretical research may be required to find how far the physical picture can be validly approximated by concepts familiar in engineering, how far, for instance, the behaviour of semi-conductor barriers and the phenomenon of injection of holes or electrons can be represented by a network of resistances, capacitances and generators. It must be essentially a common-sense codification, concerned less with accuracy, general validity and logical un-

* Based on the Chairman's Address to the Manchester and District Branch of the Institute, given on January 13, 1956

assailability than with ease of grasping what is concerned. This was as true in Isaac Newton's day as now. That practically-minded man was not prevented from formulating his laws of motion by the question whether his definitions of mass and of time were independent of one another or independent of his definition of force ; he had found a consistent set of rules which worked and could be used by intelligent people. Some of the logical difficulties are still unresolved.

That the major discoveries and laws of physics ultimately tend to become incorporated in the rules of engineering, I don't think one can doubt. I have given one ancient and one modern example ; one is reminded of others by the reverence accorded by electrical engineers to such names as Faraday, Maxwell and Kelvin, or by recalling that the discoveries of men who for the last two generations have striven merely to understand the ultimate constitution of matter are now the basis of our only serious effort to avert a famine of coal. The process is inevitable. This is far from saying that physical research should aim first to gain control over our environment ; that may be the engineers' point of view. The physicist sees that engineering is a convenient by-product of physics.

But it is not the only process ; engineering practice has often provoked entry into new realms of physics. The appearance of the steam engine in France stimulated the highly original reflections of Sadi Carnot on the conversion of heat into work, which, together with the careful observations of Joule, were later to form the basis of modern thermodynamics in the hands of William Thomson, Clausius and others. Again, the modern theoretical developments of fluid dynamics, the theory of the lift of an aircraft for instance, did not precede the design of the first successful aircraft ; they followed it. And the current theories of semi-conductor rectifiers are basically those which were formulated from a study of copper oxide and selenium rectifiers several years after these devices had become commonplace in electric circuits.

A third and quite different sort of relation arises in the field of designing scientific instruments. Here engineer and scientist must move together. There are now a bewildering number and variety of instruments which may be used alike in industrial plants or in research laboratories, from pyrometers and vacuum gauges to elaborate optical spectrometers, electron microscopes, and mass spectrometers. Also there are the high energy particle machines, the linear accelerators, electrostatic machines, cyclotrons and synchrotrons of various degrees of immensity. Some instruments can and have been designed and made on the principle that scientists state the basic design requirements and pass these to engineers to design the " ironmongery " around them, but this method rarely works well. The development of a complex instrument for general use seems to be best done by scientists and engineers working in close, almost continuous, contact and with adequate workshop resources to hand. It costs several times as many man-hours to produce a good finished design as to produce a reasonably satisfactory laboratory model. The laboratory model need only satisfy its maker, whose child it is, and who is so familiar with its minor foibles that he is often unconscious of them ; the finished design must satisfy any reasonably intelligent operator who has only a brief experience of the way it works and no sympathy with erratic behaviour or any but the rarest failure of components. To achieve this requires a great deal of mutual confidence between scientist and engineer and a surprising amount of give and take. It requires prolonged experimental work simply to decide the material or the mode of construction giving the nearest approach to the ideal combination of operating requirements, or to find ways of eliminating faults that would be tolerated in one's own apparatus. It also requires much thought in anticipating faults and in devising means of avoiding the possibility of them, even though one is not, perhaps, quite certain whether they will occur.

Thus we can distinguish three broad types of interchange between physics and

engineering—the metamorphosis of physical laws into engineering principles, the challenge to physicists to explain fully the operation of devices used in engineering, and the collaboration between physicists and engineers in perfecting elaborate scientific equipment.

Let us now see how these kinds of interchange are developing at present.

A rather new field of engineering which has been adapted from physicists' techniques is the design of high vacuum plant. Vacuum furnaces have proved to be most effective for many metallurgical processes, the melting of metals without contamination and the production of gas-free metals, solid reactions which produce hard metal-cutting materials, the vacuum sealing of metals to ceramics using hydrides of refractory metals such as titanium and zirconium, and many others. Low temperature vacuum processes for concentrating pharmaceuticals, particularly vitamin-bearing fish oils and antibiotics, and even for concentrating food flavourings such as coffee essence and fruit juice, are becoming increasingly common. Then, of course, there are vacuum plants for distilling the fluids used in vacuum pumps.

This type of engineering has been taken over from the corresponding physical techniques but is in a curiously untidy state, which makes an interesting contrast with another field which has been taken over, namely electromagnetism. The fundamentals of kinetic theory were very firmly established at about the same time as the fundamentals of electromagnetism and partly by the same genius—Clerk Maxwell—yet while electricity is an exact science, vacuum is very inexact ; and while the solutions of electromagnetic problems for all sorts of systems of conductors have been worked out, and the methods of attacking any fresh problem are established, there are, I believe, only two or three boundary systems for which the streaming flow of gas has been calculated. These are : the hole in a diaphragm (which is very simple), the circular tube of arbitrary length and diameter, and the long rectangular tube. Nor does there seem to be any immediate prospect of getting solutions of the sets of simultaneous integral equations which describe the more complex systems.

One may suggest that it is not worth making accurate calculations on vacuum systems since there are no practical, accurate and reliable methods of measuring low pressures, which is also a difficult problem. And, one may well say, why bother too much with accurate measurement of pressures when the methods of design are so rough and empirical ? There is a third awkwardness in the situation, namely that in vacuum practice one is often dealing with quite as much gas from the walls of a tube as gas which flows down it, and this may make calculations futile in certain parts of vacuum systems under some conditions. But until the calculation of flow and the measurement of low pressures are much more firmly based the subject can hardly be one which physicists can regard as satisfactorily explored, and sooner or later they will have to make it much more precise.

It seems likely that future contributions of physics to engineering will be concerned more with understanding the properties and behaviour of materials than with general laws. One set of problems which has puzzled physicists for the last fifty years, and a matter which is of the greatest importance to engineers, is provided by the mechanical behaviour of solids ; briefly, why are solids not as strong as the binding forces between their constituent atoms or ions would lead one to expect ? And why have thin filaments frequently a much greater tensile strength than larger pieces ? Furthermore, why is a single crystal of a metal so much softer than a polycrystalline piece, and why do metals usually harden on cold-working ? The study of lines of imperfections in crystals—dislocations—still in an early stage, seems likely to be the key to big advances in reconciling crystal theory with crystal behaviour. It explains plausibly why crystals which are small enough to contain no dislocations (about 1 micron) can approach the theoretical strength of the crystal ; how a few dislocations in a single crystal can allow relatively easy glide of one part of the

crystal over another ; and how a crystal containing many dislocations will become harder to distort because dislocations are surrounded by fields of local stress and these stresses may be such as to impede their further approach to one another. Further the very slow creep of metals under small stress at high temperatures, and the polygonization of strained single crystals receive plausible explanation. The theory is a complicated exercise in three-dimensional imagination and I do not intend to say more than that it seems likely to provide a much clearer understanding of the mechanical behaviour of solids than any concept yet tried, and this may, in turn, lead to new ways of obtaining desirable mechanical properties.

Another limitation of engineering materials which is beginning to yield an explanation in physical terms is that of the electric strength of solids. It now seems clear that electric breakdown of an insulator is normally an electronic phenomenon, a sort of electron runaway, but one whose nature is not clear beyond all shadow of doubt. The physical problem is basically—when do electrons run away? i.e. when do they receive energy more rapidly by acceleration in the electric field than they lose it to the crystal lattice ? The statistics of electrons moving with high kinetic energies in a solid is a subject which can only be treated by fairly drastic approximation, and one of the most successful approximations is the assumption that, in an imperfectly crystalline insulator above a certain temperature, the electrons which are moving and those which are trapped can be regarded as a gas, in which interchange of energy from one electron to another is more frequent than interchange between one electron and an atom or ion. Hence the problem should be treated on the basis of an electron gas, at a much higher " temperature " than the lattice, passing energy to the lattice and receiving energy from the applied electric field.

This leads to the result that the electric strength should diminish with rise of temperature. This is mainly because the number of free electrons in equilibrium increases with increasing temperature. At low temperatures or in good crystals, on the other hand, temperature should make very little change. This theory has enabled the electric strength of simple ionic lattices such as the alkali halides to be predicted with surprising precision *ab initio*, i.e. without any unknown constant which can be adjusted to fit the experimental results. It also explains the breakdown strength of such materials as polythene, which is independent of temperature up to about 0° C. then drops rapidly. As work in this field continues, the success of this particular branch of solid state theory becomes more and more impressive.

Still, it is not yet wholly relevant to electrical engineering for the breakdown strength predicted by theory is achieved only when the electrodes are so arranged that the field in the solid is several million volts per cm. without the field in the surrounding medium reaching the breakdown strength of that medium, usually only ten or a hundred thousand volts per cm. If this ratio of a hundred or a thousand to one is not achieved, discharges occur over the surface and it seems that, with alternating voltage at least, breakdown in the solid is often a slowly progressive process initiated by breakdown in the surrounding medium. There appear to be a variety of contributing processes of electrical breakdown, and while the ultimate and most fundamental process may well be the electronic one deducible from solid state theory, there is still plenty of scope for investigating how it comes about that this process can be initiated when the average field strength is relatively low.

Mention of discharge reminds one of the vast amount of information and experimenting with discharges in gases. This has led to a much clearer understanding of the mechanism of spark breakdown but gives little clue as to what may happen with other kinds of discharge. It is not possible, for instance, to predict the volt-current-time curve of an arc of given length and varying current, or the behaviour of an arc in a magnetic field, both questions of great importance in engineering design.

Some of the more interesting and spec-

tacular impacts of physics on engineering are those in the field of semi-conductors. The place of semi-conductors in the statistical theory of the solid state was noted by Fowler, whose ideas were elaborated by A. H. Wilson in the early 1930s. Meanwhile, a great deal of information on various oxide conductors was being accumulated without much more than a qualitative correlation between theory and experiment. A few years later three closely related models of rectifying barriers were advanced which are basically the present theories of rectification. Yet the behaviour of known rectifiers was only qualitatively similar to the theoretical predictions, and it was not possible to draw any useful conclusion regarding the way selenium rectifiers, say, should be made. So far semi-conductor physics was no more than an interesting and suggestive speculation upon the operation of rectifiers and thermistors in practice.

But about 1946 the techniques of purifying germanium had become so developed that the major quantities concerned in the theory could be measured, known impurities added, and a fairly complete correspondence established between the experimentally observed conduction phenomena and the theories developed some years earlier. The techniques of growing single crystals of this element then made possible much more refined tests of the theory than before, with the result that some of the approximations were found to be too crude, and more detailed theories were developed.

The rectifying barrier was a more difficult case. Indeed it is doubtful if the rectification at any contact between the free surface of a semi-conductor and the surface of a metal is fully understood. But the understanding of conduction in germanium and silicon made possible the synthesis of a new type of rectifying barrier without a free surface, the junction of opposite conducting types, *p* and *n*, which not only fulfils a theory based on the original models but is also a much better rectifier from all points of view (except ease of manufacture) than the empirically discovered selenium and copper oxide types.

Perhaps still more important from the engineers' point of view, a brilliant combination of experimental techniques and theoretical insight revealed the possibility of various types of solid state amplifiers and switches which is now opening up an entirely new field of engineering never before envisaged, except as a vague speculation.

Thus the science of semi-conductors has in the last twenty years developed from being an interesting commentary on some natural phenomena used by engineers, to inventing devices more convenient and efficient than could ever have been produced by mere observation and common-sense deduction, and with them a new type of circuit engineering.

Nor will the story finish with germanium and silicon. The very wide range of conducting properties exhibited by binary compounds (and even ternary compounds) is only just beginning to be explored, revealing that between such highly conducting compounds as indium antimonide with a very high mobility and small energy gap on the one hand, and the insulating alkali halides with low mobility and large energy gap on the other, there exists a great number of substances with a wealth of combinations of properties ; so such long-sought possibilities as thermoelectric generation of power or such novel conceptions as the generation of light or the intensification of pictures by electroluminescence in a solid may turn to be practical propositions.

I have left till the end the mention of the gift from physics to engineering which will perhaps overshadow all that have gone before : the use of nuclear reactions for the generation of power. I do not think there is anything of a brief general nature to be said on this topic which has not already been said by many eminent people. Its possible and probable bearing on our future economy and technology have been so widely canvassed that it would be superfluous to enlarge on it here.

There is another omission, which might perhaps irritate purists ; I have spoken at length without a single reference to engineering in its original sense of the art of making

engines of war. I don't propose to follow this up either, because the warlike applications of physics do not differ in kind, but merely in detail, from their peaceful parallels

Summarizing, then, it seems that physics, or natural philosophy, having given to engineering such principles as those of mechanics, electromagnetism, thermodynamics and a host of minor matters, is now beginning to exercise an influence in two other large fields — nuclear energy and the physical properties of inorganic solids—and that both these fields will provide problems in applied physics for large numbers of the coming generation of physicists.

Can we go further and say from where the next big advance will come ? Perhaps from some hitherto immaculately non-utilitarian branch such as astrophysics or low temperature physics. The temptation to spot winners is great, but if indulged is usually fatal. Research can be planned a little way ahead of utilitarian purposes with a fair chance, say two or three to one against, of producing either an interesting contribution to knowledge or a useful addition to technology or maybe both. But the big advances in material benefits seem generally to come as a bonus on the acquisition of knowledge. If we are tempted to plan ourselves too conscientiously to utilitarian ends we may recall that those most practical rules of engineering, Newton's laws, came from a contemplation of the motion of the stars, an occupation which in the seventeenth century could have been of practical significance only to navigators, to the more pedantic clock makers, and to those who cast horoscopes. It must still be true that the best guides to progress come from the directions intuitively taken by inquiring minds.

Conference on Degree and Diploma Courses in Applied Physics

November 15 and 16, 1956

at The Institution of Electrical Engineers

Forms of application are now available for the above Conference that has been arranged jointly by the Institute and the London and Home Counties Regional Advisory Council for Higher Technological Education. Application should be made to the Deputy Secretary of the Institute.

The purpose of the Conference is to discuss the extent to which university courses in physics meet the needs of industry and government service and whether new types of course, more strongly biassed towards applied physics, should be developed in universities and technical colleges.

It is particularly hoped that there will be a good attendance of senior industrial and government scientists.

Reviews of Books

THE MATHEMATICS OF DIFFUSION

By J. Crank

London : Oxford University Press. Pp. 347 + vi. Price 50s.

This book presents a full account of the differential equations applicable to many diffusion problems. Analytical discussions are given of a wide variety of problems, and the solutions are completed with well-drawn graphical representations. There are also chapters on finite difference methods and the measurement of diffusion coefficients. The physical problems are themselves fundamentally interesting, including progressive freezing of a liquid, tarnishing reactions at the surface of a metal and the simultaneous diffusion of heat and moisture into fibres. The book is written with an obvious competence in the mathematical sections : apart from the graphical solutions in the text, tables are appended of all the important functions and parameters needed in applying the methods described to particular problems.

The author appears to be less happy when dealing with descriptive matter. Some of the passages describing the physical aspects of the problems, which ought to form the basis for understanding and applying the mathematics, are depressingly abstruse. A few examples from the last chapter illustrate this criticism :

" This experiment in a vacuum may seem to be artificial but it illustrates that the immediate reaction of a mass of fibres when presented with a new atmosphere is to modify that atmosphere to be in equilibrium with itself at the expense of only a slight change in its own moisture content." (p. 304.)

" In such cases the solution to the problem of the simultaneous transfer of heat and vapour reduces to the sum of solutions for the ordinary diffusion of the ' normal co-ordinates ' with appropriate rates of evolution throughout the medium of the quantities they represent." (p. 313.)

" The initial fall in temperature occurs while the sheet is behaving semi-infinitely with respect to heat flow." (p. 322.)

Those who require the results of the mathematical work on diffusion which has been done within the last ten years presented in a readily usable form will be well satisfied by this book : chemists, engineers, and physicists wishing to understand and predict the behaviour of practical diffusion systems may well have wished for greater lucidity in the presentation.

I. I. Berenblut.

AN APPROACH TO MODERN PHYSICS

By Professor E. N. da C. Andrade, D.Sc., Ph.D., F.R.S.

London : G. Bell and Sons Ltd., 1956. Pp. 232. Price 25s.

" Let us consider the ether of space, which, when the writer was a student—happy days ! — dominated theoretical physics," says Professor Andrade in his concluding chapter on the Uncertainty Principle. The interjection invites one's own student reminiscences of a later period, when theoretical physics was not only dominated but positively cowed by a mere couple of quantum numbers, and the one readable and coherent picture of the situation in all its aspects was Andrade's *Structure of the Atom*—a Homeric work, even to the thrill one got on first looking into it. Not so long after this, among the memorable interpretations of science for the layman of the early 1930s came his *Mechanism of Nature ;* this book, after passing through five editions, has been re-written to give an account of the present position under the new title *An approach to Modern Physics.*

While many recent developments in nuclear physics, cosmic rays and the numerous new particles, radio-astronomy, and the properties of matter at very low temperatures are admirably explained, the fundamental ideas

used in approaching the advancing front are set clearly before the reader. In about half a page, for example, the author gives the best simple explanation of the Michelson-Morley experiment that I have ever seen. There is a particularly good chapter on solids and liquids, where he shows how the unspectacular but important work on metals which was one of his own interests (although he does not mention this) fits into the wider picture. The underlying aim of the book is not to dazzle the reader with a list of achievements, but to show him how these things have happened to the workers who have selected their problems, asked carefully formulated questions, and interpreted their results within this framework. Thus, of C. F. Powell's work, which the author describes fairly fully, he says " the general set-up is one that has traditionally served well in British physics—simple means, sound foundation, convinced confidence, and genius," a characteristic appraisal in terms of the values he would propagate.

The writing is undiluted Andrade at his best, founded on a basis of scholarship and human interest, and devotion to the work and thought of Newton and the memory of Rutherford. Looking for the poetic strain, one finds it in an Eliot-like allusiveness which rings a bell remotely in the memory ; for this reason, the professional scientist will probably savour it even more fully than the general reader for whom this most delightful book is primarily intended.

G. R. NOAKES.

VALENCY AND MOLECULAR STRUCTURE

By E. Cartmell and G. W. A. Fowles

London: Butterworths Scientific Publications. Pp. 256 + xi. Price 32s. 6d.

The quantum theory is fundamental for the development of modern theories of valency and molecular structure, and because of the overwhelming importance of the valency concept in chemistry many teachers nowadays are of the opinion that, in spite of the pedagogic difficulties, a student should be introduced to wave-mechanics and some of its simpler chemical applications quite early in his university course. The average student of chemistry is not equipped, in his earlier years at least, to read the standard works on wave-mechanics; the work under review is one of the latest of many attempts to present the subject to him in a (mathematically) less formidable guise.

In the first half of the book the authors aim to provide an elementary introduction to the quantum theory of valency (at a substantially lower mathematical level than, say, Coulson's *Valence*) and in the second half they survey its application to actual problems of molecular structure. Since the fundamental principles have been established for nearly thirty years the first half of the book covers familiar ground and the interest to a reviewer therefore lies mostly in the method of presentation. Although the authors have made a valiant attempt to grapple with the pedagogic difficulties they have not been entirely successful, chiefly because of carelessness about details, but partly (although this must be entirely a matter of opinion) because of faulty judgement in the mode of presenting various subjects. For example, twenty-one references to " canonical forms " are listed in the index but nowhere in the book is the term defined; if the student, seeing this portentous phrase, asks " Does the Claus (diagonal) formula for benzene represent a canonical form, and if not why not? " this book will not help him to find an answer. In fact if the word " canonical " were deleted throughout the book the student's ignorance would be imperceptibly increased and his bliss would be considerably augmented. At the beginning of the chapter on the valence-bond method (page 70) the authors " mention two general principles that we shall use quite frequently; one is the variation principle and the other is the principle of linear combination." So far as I can see they do not use the variation principle at all; they merely state (sometimes rather imprecisely) some results which have been obtained by its application, which is not at all the same thing. They are

mistaken, in my view, in giving the impression (perhaps unintentionally) that the principle of linear combination (i.e., of superposition) is something rather esoteric on a par with the variation principle; students can, and ought to be, shown the essential simplicity and the wide applicability of this principle by means of both physical and mathematical examples so that when they encounter it in the context of wave-mechanics they will take it for granted. In this book the authors have in fact taken it for granted at a much earlier stage (page 25), in discussing standing waves; this is where it should have been introduced explicitly. There are many good diagrams, but some of them are not sufficiently carefully thought out; for example fig. 37, page 107, shows p orbitals overlapping less than s orbitals whereas the text explains that p orbitals overlap considerably more than s orbitals.

The second half of the book reviews much of the work which has been done in recent years on the application of wave-mechanical principles to the interpretation of the structures of simple inorganic molecules, complex compounds and electron-deficient molecules. It is well done on the whole but the authors, in striving to convince the reader of the power and universality of modern valency theory, are sometimes not sufficiently critical and tend to be misleading about experimental methods. A few errors of fact are excusable in a work which contains so much information, but the authors should not have invented a mis-statement such as (page 109) "It is well established, however, from X-ray studies, that both bonds in such simple compounds of bivalent beryllium are collinear and of equal strength."

Although the book cannot be unreservedly recommended it contains much that is good; many teachers will wish to possess it and will no doubt find that with suitable warnings it can be recommended to their students. It is well produced, with very few misprints, and there are good indexes and lists of references.

E. G. Cox.

PRACTICAL SOLUTION OF TORSIONAL VIBRATION PROBLEMS (Volume I—Frequency Calculations)

By W. Ker Wilson

London : Chapman and Hall Ltd. Pp. 704 + xxxii. Price £5 5s.

This is a third and revised edition of Dr. Ker Wilson's work on torsional vibrations ; the last edition had appeared in 1940. It is not a book for the general reader, but an essential source book for the specialist. The book opens with a very interesting historical introduction, a chapter on simple systems and a chapter on frequency tabulation. A chapter on multi-mass systems is followed by three chapters on the torsional vibrations of geared systems of various degrees of complexity. Two chapters are devoted to the effective inertia method, and one chapter each to coupled torsional and flexural vibrations of engine systems, equivalent masses, and equivalent shafts. The last chapter summarizes official requirements relating to vibrations. There is also an extensive bibliography.

E. K. Frankl.

ELECTRICITY AND MAGNETISM (Volume I)

By J. H. Fewkes, Ph.D., F.Inst.P., and J. Yarwood, M.Sc., F.Inst.P.

London : University Tutorial Press Ltd. Pp. 768 + vii. Price 36s.

This undergraduate textbook, although the first of a series of two volumes, is nevertheless self-contained and deals with magnetism, electrostatics, direct and alternating current electricity, electromagnetic radiation and the fundamentals of electronics and radiocommunication. The second volume will be devoted to atomic physics. Both the authors are senior teachers in physics at The Polytechnic, Regent Street, and are thus well versed in the requirements of students studying for first degrees in physics, particularly the B.Sc. General and Special degrees of the University of London. Such students will find this textbook ideal for their use. The some-

what unusual emphasis in the latter part of the book on electronics provides for the more technical needs of the Graduateship examination of The Institute of Physics and of some university degree examinations. The treatment is along conventional, historical and classical lines and preference is given to the standard, well-tried methods to the exclusion perhaps of more interesting but less fundamental experimental procedures and apparatus. A previous knowledge of the subject corresponding to about the Advanced Level of the General Certificate of Education is assumed and the standard of mathematics required is that of a first-year university course. Vector analysis is relegated to a final chapter ; the *j*-notation is used but not extensively ; and some may criticize the authors for their elaborate and detailed mathematical derivations. The more difficult sections of the text are indicated by an asterisk and the student can avoid these at first reading. An especially welcome and valuable feature is the large number of well-chosen worked examples and the collections of questions from various university degree examination papers. A good account is given of the different systems of units, including the mksA system, but it is mainly the unrationalized cgs electromagnetic and electrostatic units which are used in the text, though occasionally, in order to give the reader practice with rationalized mks units, questions involving these units are included.

For its cost *Electricity and Magnetism* is remarkably good value and will be generally welcomed by both students and teachers. Nevertheless it has some peculiarities. For instance, there are no illustrations other than line drawings which it is true are clearly and well drawn. But the reader is left to imagine what a resistance box, galvanometer, potentiometer, valve, cathode-ray tube, etc., look like from the outside. There is a lack of balance between the various sections as to the amount of physical and technical data to be included ; for example, why give tables of the properties of various commercial magnetic materials and of the relative permittivities of numerous substances and not also a table of resistivities and resistance temperature coefficients of the more common substances ? It is a pity that the authors did not think fit to introduce Thevenin's theorem and to use it to simplify the work involved in the discussion of the Wheatsone bridge, and it is surprising that neither the Weidemann-Franz ratio nor the semi-conductor receive even a brief mention. Bloch zones between magnetized domains are referred to, though the " fiction " of the magnetic pole is retained, as also the study of the magnetic shell. Magnetrons and klystrons are included in the various electronic devices described, but under the heading of the photoelectric effect photoemission only is discussed and even then no mention is made of the photomultiplier.

Electricity and magnetism, as indeed all branches of physics, have expanded enormously during the last few decades and if one includes also electronic physics as the authors of this textbook have done, the selection of material becomes extremely difficult and the above-mentioned peculiarities should not therefore be regarded as important faults. They may be useful as suggestions to the authors, and it may be useful also to suggest that in future editions the volume be separated into two parts, so as to give sufficient space, with some suitable rearrangement, for some of the individual aspects of the subjects to be dealt with more adequately and with a more modern approach.

S. WEINTROUB.

ELEMENTARY PHYSICS

By G. Stead

London : J. and A. Churchill Ltd. Pp. 532 + xvi. Price 21s.

Most people interested in textbooks at this level will be familiar with this work since it has now been printed for the fifteenth time. It remains a very good and readable text, presenting a condensed, and somewhat simplified, version of the physics usually studied for the Advanced level of the G.C.E., the material being particularly adapted for the

first medical examinations. In the new edition (the ninth) the text has been reset in a much more attractive fount. Only a few of the blocks have been changed, with the result that the general appearance still has a pre-war touch. No more than a few minor changes in the text-material have been made as this was brought up to date in the seventh edition in 1947. Whilst the book was being reset, greater use might have been made of the opportunities presented for bringing parts of it more into line with present-day teaching. For instance, secondary electrode reactions are, in general, no longer used as explanations of electrolytic phenomena, even at Ordinary level. The average pupil using this book will be much more familiar with the elementary aspects of the atomic theory than he would have been in 1924, a fact which might have been used to advantage. But these are suggestions rather than serious criticisms. There is no doubt that the book will continue to be a most useful teaching medium for many more generations of students.

R. STONE.

THE RELATIONS BETWEEN SCIENTIFIC RESEARCH IN THE UNIVERSITIES AND INDUSTRIAL RESEARCH

Edited by V. E. Cosslett, M.A., Ph.D., F.Inst.P.

London: The International Association of University Professors and Lecturers. Pp. 187. Price 15s.

This report is concerned primarily with the ways in which research in universities is financed, and with some of the special problems facing universities and their staffs when they undertake sponsored research. There is also a brief review of the organization of research in Great Britain, and some comment on the general relations between industry and the universities. The report was prepared by a sub-committee of the Association of University Teachers and thus expresses only one point of view—some of the opinions expressed will certainly not be generally accepted outside the universities. It does, however, provide an excellent basis for the discussion of topics which are of interest and importance, not only to university staffs but to all concerned with research.

A substantial part of the report consists of the results of a statistical analysis of the replies to questionnaires sent to universities and university staffs asking for information about the ways in which their research activities are chosen and financed. The results are analysed by subject and by university and the tables given contain a great deal of information that is difficult to summarize.

The main conclusions reached are :

(i) 8·5 per cent of research students and 25 per cent of senior research workers receive their stipends direct from industrial sources.

(ii) 6 per cent of research projects in the universities are financed wholly, and 32 per cent partially from industrial sources.

(iii) 18 per cent of university research workers undertake consultative work for outside bodies.

(iv) More than a million pounds is given to the universities by industry each year, mainly for the support of research.

The comment on these conclusions, and the discussion of administrative, economic and ethical problems associated with sponsored research, expose many aspects of the situation but it is unfortunate that, in the body of the report, it is not always easy to be clear as to whether a particular statement is based on the statistical evidence or is the opinion of the Sub-Committee responsible for the report.

Both the data and the comments are well written and presented but one wonders whether it is really fair to condense the conclusions already given into the statement that " approximately 20 per cent of the research effort to the scientific and technological side of British universities is related more or less directly to industrial needs "—a statement that has already been reported elsewhere as one of the conclusions of this report. It is also rather surprising,

particularly in view of the stress quite rightly laid in the report on the importance of freedom of publication, that no attempt was made in compiling the questionnaire to obtain evidence as to how real this particular danger of sponsored research is. The absence of such evidence makes the comment in the report seem rather pointless.

In view of the title of the report it is perhaps not unnatural that, despite the fact that it is believed that nearly 50 per cent of the money for university research comes from State research contracts, the sub-committee should nevertheless be preoccupied with the problems arising when a university undertakes work for industry. However, whilst there will be general agreement that the universities must safeguard their freedom and independence, it should not be forgotten that, more than ever before, contacts between industrial and university research workers can benefit both industry and the universities. It is rather disturbing, therefore, to see the almost completely negative attitude adopted in this report, not only towards sponsored research, but to industry in general. The report includes several recommendations aimed at restricting rather severely the amount of direct contact between industry and the universities and at the same time pleads that bequests from industry to the universities should not be "ear-marked" for particular purposes. Industry is, and will continue to be, such an important part of modern life—and 86 per cent of the research workers replying to the questionnaire agreed that their acceptance of outside work was in the interests of the Department as a whole—that it would seem desirable for the universities to maintain and even to increase their contacts with industry. Perhaps if university research workers were encouraged to engage more often in those basic problems of applied research that are of industrial importance, industry might feel it less necessary to ear-mark its bequests and this might prove a more effective way of preserving the universities' traditions than will the restrictions recommended in this report.

A. E. DE BARR.

STRENGTH AND ELASTICITY OF MATERIALS. (Solutions of Examination Questions of the University of London. Volume IV)

By W. H. Brooks

London: Macdonald & Co. Pp. 464. Price 35s.

This volume of 464 pages contains solutions to papers set in the Part II (External) B.Sc. (Engineering) examinations of the University of London. The period covered is 1941-1952 inclusive.

The solutions are set out in considerable detail; the book should be very useful to candidates preparing for these examinations.

E. K. FRANKL.

INVESTIGATIONS ON THE THEORY OF THE BROWNIAN MOVEMENT

By Albert Einstein

New York: Dover Publications, Inc. Pp. 124. Price $1.25.

This little book contains the complete text of five papers on Brownian Motion written by Einstein during the years 1905-8, and published in the *Annalen der Physik* and the *Zeitschrift für Elektrochemie*.

Students of physics, who too seldom these days go back to the original sources, will find it a useful discipline as well as a pleasure to read these papers by one of the greatest mathematical physicists of all time. How re-assuring to read: "the information available to me . . . is so lacking in precision, that I can form no judgment in the matter"; and how charming "I hope I may be able by the following to facilitate for physicists who handle the subject experimentally the interpretation of their observations . . ."

There are some helpful, interesting and authoritative additions and comments by Dr. R. Furth. The translation, which first appeared in 1926, is now re-published unabridged and unaltered in this new form. For later developments the students must, of course, turn elsewhere.

J. TOPPING.

News of Members

FELLOWS

Professor E. N. da C. Andrade has accepted the invitation of the Council of the Royal Society to deliver the Rutherford Memorial Lecture for 1957 in Australia.

J. C. Jones is now a Principal Assistant Physicist at the Sheffield National Centre for Radiotherapy.

E. G. Richardson has been appointed Professor of Acoustics at the University of Durham, Newcastle Division, and Leverhulme Research Fellow for one year.

G. L. Rogers has taken up a Lectureship in Natural Philosophy at the University of Aberdeen.

K. K. Schiller has joined the Research Department of the British Plasterboard Co. Ltd., and taken over the Department of Technological Physics.

C. Sykes has been awarded the Bessemer Gold Medal for 1956 in recognition of his distinguished contribution to the study of alloy systems, particularly in the field of order-disorder changes, and the effect of such changes on the physical properties of alloys.

Sir Henry Tizard will receive the honorary degree of Doctor of Science from the University of London on November 23.

F. Twyman has been awarded the Medal of the Society for Applied Spectroscopy of America in recognition of his contributions to the design of spectrographs, and his early advocacy of industrial spectrochemical analysis.

C. G. Webb is now working in the Colonial Liaison Section, Building Research Station, Garston, Herts.

G. A. Whipple has been appointed President of the Scientific Instrument Manufacturers Association for 1956-7. He was previously Vice-President.

H. Wilman has been appointed to the University Readership in Applied Chemical Physics tenable at Imperial College, London.

ASSOCIATES

A. C. Copisarow has been elected to the 1956 Council of Europe Research Fellowship.

H. Howells now holds the post of Manager of the Health Physics and Safety Group at the United Kingdom Atomic Energy Authority's Windscale Works, Cumberland.

P. Lord is now with the Aluminium Labpratories Ltd., Banbury, Oxon.

R. Whitmore has been awarded a Travelling Fellowship by the Anglo American Corporation of South Africa.

GRADUATES

J. Ashton is now working at Cookridge Hospital, Leeds, in the High Energy Radiation centre.

J. M. Bryce is employed in the Research Laboratory of the British Thomson-Houston Co. Ltd., Rugby.

A. L. Davies has recently been appointed Principal of the College of Further Education, Aberdare, Glam.

W. A. Dodd is now a lecturer in the School of Technology, Ipswich.

J. B. Dunne has taken up a post with the Dowty Group of Cheltenham.

I. D. C. Gurney is now employed as Scientific Officer in the Physics Department of the Radar Research Establishment, Worcs.

J. G. Padbury has been promoted to Technical Officer in the Instrument Development Section at the Imperial Chemical Industries Ltd., Plastics Division.

D. Pendleton has been appointed Quality Controller at Albert E. Reed & Co. Ltd., Kent.

H. Rindl has obtained a position as a research physicist at the Dunlop Research Centre, Birmingham.

J. S. Rollett has returned to England and is now working at the Chemical Crystallography Laboratory, University Museum, Oxford.

Miss D. Saltmarsh is now employed by Denis Ferranti Meters Ltd., of Bangor.

R. W. Snell is now in Iraq, having been seconded from the British Petroleum Co. Ltd. to the Mosul Petroleum Co. Ltd.

D. G. B. Thomas is now with the British Rayon Research Association.

R. H. de Vere has recently taken up an appointment with the British Rayon Research Association.

I. Woffindin is now working in the Research and Development Branch of the United Kingdom Atomic Energy Authority, Springfields.

Forthcoming Institute Meetings

Oct. 15 Scottish Branch

In the Natural Philosophy Department, University of Edinburgh, 7.15 p.m.

Chairman's address

" *Physics and Physic* "

DR. J. M. A. LENIHAN, F.INST.P.

(Regional Physicist, Western Regional Hospital Board)

Oct. 16 Midland Branch At Regent House, Birmingham, 7 p.m.

" *The Physics of Clothing* "

MR. W. H. REES, F.INST.P.

(British Cotton Industry Research Association, Manchester)

Oct. 16 Electronics Group At the Institute's House, 6.30 p.m.

" *High Vacua* "

MR. M. E. HAINE, F.INST.P.

(Associated Electrical Industries Ltd., Research Laboratory, Aldermaston)

Oct. 17 London & Home Counties Branch At the Institute's House, 6.30 p.m.

" *Physics below one degree Absolute* "

DR. E. MENDOZA

(University of Bristol)

Tea will be served at 6 p.m.

Oct. 17 North Eastern Branch

At the University Science Laboratories, Durham, 6.15 p.m.

" *The Place of Experimental Physics in University Teaching* "

DR. H. J. J. BRADDICK

(University of Manchester)

Tea will be served at 5.30 p.m.

Oct. 19 Non-Destructive Testing Group — At the Institute's House, 6.30 p.m.

"*Fluoroscopy, with an enlarged image*"

MR. R. HALMSHAW, A.INST.P.
(Armament Research and Development Establishment, Woolwich)

Oct. 22 Scottish Branch

In the Natural Philosophy Department, University of Edinburgh, 7.15 p.m.

"*Guided Missiles*"

MR. J. J. GAIT, A.INST.P.
(Guided Weapons Department, Royal Aircraft Establishment, Farnborough)

Oct. 23 Scottish Branch

In the Natural Philosophy Department, University of Glasgow, 7.15 p.m.

"*Guided Missiles*"

MR. J. J. GAIT, A.INST.P.
(Guided Weapons Department, Royal Aircraft Establishment, Farnborough)

Oct. 24 Yorkshire Branch — In the Physics Department, University of Leeds, 3 p.m.

"*Some Properties and Uses of Man-made Fibres*"

MR. F. CHARNLEY, F.INST.P.
(British Rayon Research Association, Manchester)

Oct. 31 London & Home Counties Branch — 3 p.m.

Visit to the Research Laboratory of Associated Electrical Industries, Ltd.
followed at 5.40 p.m. by

"*Mechanisms of Friction and Wear*"

DR. W. HIRST, F.INST.P.
(Research Laboratory, Associated Electrical Industries Ltd.)

Tea will be served at 5.15 p.m.

(Admission by ticket obtainable from the Deputy Secretary)

Nov. 9 Manchester & District Branch

In the Bragg Building, University of Manchester, 6.45 p.m.

"*Nuclear Magnetic Resonance*"

PROFESSOR E. G. COX, F.INST.P., F.R.S.
(University of Leeds)

Nov. 9 South Wales Branch — At the University College, Cardiff, 5.15 p.m.

"*Magnetism and Colour*"

PROFESSOR M. H. L. PRYCE, F.R.S.
(University of Bristol)

Tea will be served at 4.30 p.m.

Nov. 9 Industrial Spectroscopy Group — At the Institute's House, 5.30 p.m.

Group Annual General Meeting
followed by
"*Cerenkov Radiation : its physical principles and applications*"
DR. J. V. JELLEY
(Atomic Energy Research Establishment, Harwell)
Tea will be served at 5 p.m.

Nov. 13 Electronics Group — At the Institute's House, 5.30 p.m.

"*Luminescence and Photoconductivity*"
DR. D. A. WRIGHT, F.INST.P.
(The General Electric Co. Ltd., Wembley)
Tea will be served at 5 p.m.

Nov. 13 Scottish Branch

In the Natural Philosophy Department, University of Glasgow, 7.15 p.m.
"*Fundamental Particles*"
PROFESSOR J. C. GUNN
(University of Glasgow)

Nov. 15 Midland Branch

At the Birmingham Exchange and Engineering Centre, 7 p.m.
Branch Annual General Meeting
followed by
Chairman's address
"*High Speed Rotation*"
PROFESSOR P. B. MOON, F.INST.P., F.R.S.
(University of Birmingham)

Nov. 15 Liverpool & North Wales Branch

In the Physics Department, University College of North Wales, Bangor, 5.45 p.m.
"*Relativity and Space Travel*"
PROFESSOR H. DINGLE
Tea will be served at 5 p.m.

Nov. 15–16 The Institute of Physics — At the Institution of Electrical Engineers

Joint Conference
with the London and Home Counties Regional Advisory Council for Higher Technological Education
"*Degree and Diploma Courses in Applied Physics*"

(Details and forms of application may be obtained from the Deputy Secretary of the Institute)
A fee of one guinea will be charged to all attending.

The Institute's Journals

PRINCIPAL CONTENTS OF THE OCTOBER, 1956, ISSUES

Journal of Scientific Instruments: Volume 33, No. 10

SPECIAL ARTICLE

Fine measurements. By J. R. Adams (*Taylor, Taylor and Hobson Ltd., Leicester*).

The limitations of the existing legal standards of linear measure are considered. The use of light waves as a universal reference of linear measure depends on the availability of a source of truly monochromatic light and considerable progress has been made using the isotope ^{198}Hg. Many aspects of engineering require measurements accurate to a few micro-inches and instruments capable of meeting such demands have been designed. Several typical instruments, together with details of the principles on which they are based, are briefly reviewed.

ORIGINAL CONTRIBUTIONS

A radioactive ionization gauge and its application to the measurement of latent heat of vaporization. By J. H. Beynon, A.Inst.P., and G. R. Nicholson, A.Inst.P. (*Imperial Chemical Industries Ltd., Dyestuffs Division, Blackley, Manchester, 9*).

A radioactive ionization gauge useful in the range of pressures 10^{-5} to 10mm of mercury, and its application to the determination of the latent heat of vaporization or sublimation of organic compounds having vapour pressures in the above range up to 200° C, are described. The instrument uses an 0·5 mc sealed radium source for ionization of the vapour and an electrometer amplifier for measuring the ionization currents produced. Values for the latent heats of fourteen compounds are given.

An alinement and co-ordinate system for nuclear emulsion stacks. By E. Silverstein and W. Slater (*Enrico Fermi Institute for Nuclear Studies, University of Chicago, Illinois, U.S.A.*).

Problems of scanning, trace-through and measurement in nuclear emulsion stacks can be simplified by the use of a co-ordinate system photographed directly on to the face of each pellicle. A method of making and printing a suitable grid that intercepts less than ½% of the useful area, as well as the advantages arising from its use, are described.

A miniature eight-channel pressure recorder. By H. M. Nelson and G. A. Parker (*Aeronautical Research Laboratories, Department of Supply, Melbourne, Australia*).

A recorder is described which has been used for pressure plotting in free-flight models at supersonic speeds. The recorder can be fitted with any combination of pressure sensitive units with ranges of 0–10, 0–20 or 0–40 lb/in.^{2} Stylus-on-celluloid recording is used and the total duration of the record is about 40s. Overall accuracy under normal conditions of use approaches ±1% of full-scale deflexion.

A high-temperature micro-thermostat for X-ray studies on single crystals of appreciable vapour pressure. By P. J. A. McKeown (*Imperial College, London*).

A furnace is described to heat slightly volatile specimens up to 1250° C for experiments with an X-ray single-crystal spectrometer. The thermal expansion of alumina at right angles to its hexagonal axis is found to be $L/L_0 = 1 + 6{\cdot}07_4 \times 10^{-6}T + 1{\cdot}86 \times 10^{-9}T^2$, up to 1230° C.

The application of pneumatic gauging to high precision linear measurement. By J. C. Evans and I. G. Morgan (*National Physical Laboratory, Teddington, Middlesex*).

The paper describes the application of pneumatic gauging to the precise measurement of the variation in thickness, in each of the three principal directions, of a nearly perfect cube recently used at the National Physical Laboratory in a new determination of the density of mercury by the principle of Archimedes. After discussing the theoretical basis of the method, the experimental arrangements are described and illustrated. It was established that the variations in thickness could be determined with an accuracy of $\pm 1 \times 10^{-6}$ in. ($\pm 0{\cdot}025\mu$). Since one of the chief objects of the paper is to draw attention to some of the advantages of the pneumatic gauging technique for linear measurement, mention is made of other uses of the technique at the Laboratory which demonstrate its comparative simplicity and wide flexibility.

A simple scanning mechanism for X-ray diffraction. By G. W. Smith, A.Inst.P., and R. M. Hinde, A.Inst.P. (*British Insulated Callender's Cables Ltd., London, W.12*).

A simple scanning mechanism is described for the X-ray investigation of preferred orientation in coarse-grained wires, by means of which the spottiness normally present in the diffraction patterns from such specimens is transformed into smooth variations of intensity on the Debye-Scherrer rings. The device is attached to a Unicam single-crystal goniometer and permits the non-repetitive scanning of a continuously rotating specimen. In its present form specimen lengths of about 5mm can be scanned.

A simple vacuum leak detector using a radio-frequency mass spectrometer. By P. F. Váradi and L. G. Sebestyén (*Research Institute for Telecommunication, Budapest, Hungary*).

A simple vacuum leak detector, based on the radio-frequency mass spectrometer principle, is described. In the pressure range of 10^{-3}—10^{-7} torr leaks of the order of $2{\cdot}8 \times 10^{-8}$ l.torr/s can be detected. The instrument may also be used as a conventional ionization manometer.

A brief description of the principles and some details of the construction of the tube and of the portable electronic equipment are given.

An instrument for the continuous measurement of shrinkage of textile yarns. By R. A. E. Ellis (*Imperial Chemical Industries Ltd., Millbank, London*), K. W. Hillier and A. B. Thompson (*Imperial Chemical Industries Ltd., Fibres Division, Harrogate*).

The yarn is fed from a bobbin at a fixed rate into a hot-air treatment chamber. After passing over a tensioning device it is withdrawn at a variable rate so that the tension and length of yarn in the chamber (and therefore the time of heat treatment) are held substantially constant. The tension is known and adjustable. The shrinkage under these controlled conditions is derived from the ratio of input to output rates, and is displayed numerically as a percentage. After a bobbin has been knotted in and the instrument started, a fixed length of yarn is tested automatically.

A portable instrument for respirable dust sampling. By R. J. Hamilton, A.Inst.P. (*National Coal Board, Mining Research Establishment, Isleworth, Middlesex*).

Dust-laden air is drawn into the instrument, which is known as the long running thermal precipitator, by means of a clockwork-driven diaphragm pump. Passage through a horizontal elutriator removes all but the respirable fraction which is then deposited on a single horizontal microscope slide by a combination of gravity settlement and thermal precipitation.

A single sample covers up to eight hours' operation, giving a measure of average dustiness. Evaluation is normally by visual microscopy, but the method of collection employed provides a deposit particularly well suited to bulk evaluation techniques.

The instrument is "intrinsically safe" for use in gassy coal mines, self-contained, and simple to operate. Extended pit trials have proved it to be robust and reliable and to give results in agreement with those obtained by the conventional thermal precipitator.

LABORATORY AND WORKSHOP NOTES
NOTES AND NEWS
CORRESPONDENCE
NEW INSTRUMENTS, MATERIALS AND TOOLS
NOTES AND COMMENTS

British Journal of Applied Physics: Volume 7, No. 10

SPECIAL ARTICLE

Neutron radiography. By J. Thewlis, F.Inst.P. (*Atomic Energy Research Establishment, Harwell, Didcot, Berks*).

The absorption of neutrons by matter is considered and the *raison d'être* of neutron radiography explained. The production and detection of neutrons are described and details are given of the techniques used for neutron radiography at Harwell. Some examples of neutron radiographs are reproduced and discussed.

ORIGINAL CONTRIBUTIONS

Reactions occurring during decomposition of alkaline earth carbonates on tungsten. By M. A. Cayless, A.Inst.P., and B. N. Watts, A.Inst.P. (*The British Thomson-Houston Co. Ltd., Rugby*).

Analysis of the gases evolved during decomposition of alkaline earth carbonates on tungsten coiled cathodes shows that carbon dioxide, carbon monoxide and hydrogen are the principal gases evolved. The ratio of carbon dioxide to carbon monoxide is found to be markedly dependent on the decomposition schedule, varying widely with temperature and speed of exhaust. It is shown that the carbon monoxide is produced during the formation of a basic tungstate interface

of the type $(Ba, Sr, Ca)_3 WO_6$. The chemical reactions involved are discussed and it is shown that none of these reach equilibrium during normal decomposition schedules. The rate of formation of free barium in the completed cathode is determined by the amount of interface produced during breakdown.

The dynamic magnetostriction of nickel-cobalt alloys. By C. A. Clark, A.Inst.P. (*The Mond Nickel Co. Ltd., Birmingham*).

The magnetostrictive properties of binary nickel-cobalt alloys in the range 0–23% cobalt are discussed, with particular reference to the use of these materials for transducers. Measurements, at various polarizing fields, of the electromechanical coupling coefficient, reversible permeability and Young's modulus are described. Various criteria which govern the choice of magnetic materials for ultrasonic transducers are discussed and it is shown that two alloys, containing respectively about 4·4 and 18·4% cobalt, give good performance as transducer materials.

The use of the stereoscopic tilt device of the electron microscope in unit-cell determinations. By J. A. Gard (*University of Aberdeen*).

An improved method is detailed, making use of electron diffraction of individual crystals in the electron microscope, for determination of the unit-cell dimension most nearly parallel to the electron beam. A series of diffraction patterns is recorded from a crystal tilted through known angles by the device normally used for making stereomicrographs. One of these patterns serves as a datum, for location on each of the others of the centre of its almost circular Laue zones. A new method is described for calibration of the instrument without using additional apparatus ; all the factors which vary with the electron-beam potential can then be derived from a single diffraction patttern of a standard substance. A graph has also been prepared to allow correction of errors in calculation due to large angles between the " third-row " axis and the electron beam. The improvement in accuracy due to the procedure is illustrated by results obtained using crystals of known unit-cells.

A possible source of error in the interpretation of electron diffraction patterns. By G. D. Archard, A.Inst.P. (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

It is shown that a slight degree of preferred orientation of the crystallites in an electron diffraction specimen may be represented as the combination of two types of orientation which produce different kinds of distortion in the diffraction pattern. Unless special precautions are taken, these may lead to erroneous values of the Bragg angles deduced from ring radii.

The flow of air through beds of charcoal. By W. M. Jones, A.Inst.P. (*University College of Wales, Aberystwyth*).

It is shown experimentally that the flow of air through beds of irregular porous granules of charcoal may be correlated with that through beds of solid spheres by using the usual equations for flow through granular beds. The envelope specific volumes of the charcoal granules are found with mercury after impregnating the granules with paraffin wax, and the envelope specific surface areas of the granules are deduced from measurements of the projected area and shape of the granules, according to the procedure laid down by Heywood.

A replica technique for particle surfaces. By J. Marriott, Grad.Inst.P. (*Imperial Smelting Corporation Ltd., Avonmouth*).

Difficulty is often experienced in the interpretation of electron micrographs of pigments as surface detail cannot normally be observed. A simple technique for the preparation of shadowed carbon replicas of zinc sulphide and lithopone is described. The use of a selective leaching agent permitting differentiation of the zinc sulphide and barium sulphate in lithopone is demonstrated.

Defects in germanium crystals grown from the melt. By E. Billig, F.Inst.P. (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

Thermal stresses arising from differential shrinkage as the crystal cools down from the freezing point to room temperature are considered as a major source of structural defects. The distribution of etch pits over various parts of a crystal has been studied and correlation has been obtained with the lifetime of minority carriers and with transistor action.

The properties of high-pressure steady-state discharges in hydrogen. By W. A. Gambling and H. Edels (*University of Liverpool*).

The results of a large number of measurements of total voltage, voltage gradient, current density and excitation temperature over a range of current, pressure, gap length and electrode condition for high-pressure steady-state discharges in hydrogen are given. Tungsten and copper electrodes were used as these are typical refractory and non-refractory materials respectively. The results show that in the absence of metal vapour the cathode and column regions are quite independent, the state of one not affecting that of the other. With increasing current a change from the glow to an arc column occurs at a critical value of the gas temperature. At short gaps the column transition current is modified by heat transfer with the electrodes. With tungsten electrodes, increase in current causes a continuous transition between glow and arc at the cathode which is due to thermionic emission. With copper electrodes the cathode transition is discontinuous, erratic and independent of cathode temperature, being a function rather of the surface condition.

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